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Ethnic Differences in the Effects of the DASH Diet on Nocturnal Blood Pressure Dipping in Individuals with High Blood Pressure

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Abstract

BACKGROUND—Ethnic differences in nocturnal blood pressure (BP) dipping may contribute to the increased risk for adverse cardiovascular events noted in African Americans (AAs). The DASH (Dietary Approaches to Stop Hypertension) diet has been shown to be efficacious in lowering clinic and ambulatory BP; however, the effect of the DASH diet on BP dipping is unclear.

METHODS—One hundred and eighteen men and women with high clinic BP (systolic BP (SBP) 130–159; diastolic BP 85–99) and above ideal body weight were randomized to a DASH diet intervention or to a usual diet control (UC) condition. Measures of 24-h ambulatory BP were obtained at baseline and at the end of the 4-month intervention period.

RESULTS—At baseline, AAs (n = 43) displayed blunted nocturnal SBP dipping compared to Caucasians (CAs; n = 75) and were more likely to be categorized as nondippers (<10% nocturnal decline in SBP, AAs: 51% vs. CAs: 27%). AAs randomized to the DASH diet intervention showed a significant improvement in SBP dipping postintervention compared to AAs in the UC condition (P = 0.04), whereas there was no appreciable change in SBP dipping in CAs (P = 0.72). Following the intervention, ethnic differences in SBP dipping were no longer statistically significant (nondipper status: AAs: 44% vs. CAs: 32%; P = 0.19).

CONCLUSIONS—Our study provides preliminary evidence suggesting that in overweight men and women with high BP, AAs may be especially likely to benefit from augmented SBP dipping associated with consumption of the DASH diet.

Keywords

blood pressure; DASH diet; ethnicity; hypertension; nocturnal blood pressure

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Cardiovascular disease is the leading cause of morbidity and mortality in the United States[1] particularly among African Americans (AAs) as compared to whites.[1–3] AAs show higher nocturnal blood pressure (BP) and a blunted decline in BP from day to night.[4–8] This attenuated decline in night-time BP relative to daytime BP, often referred to as "nondipping," is associated with elevated risk for cardiovascular disease in normotensive and hypertensive populations,[9–11] and has been linked to development of subclinical atherosclerosis,[12] left ventricular hypertrophy,[13] congestive heart failure,[14] and all-cause mortality.[15,16]

The etiology of ethnic differences in BP is unclear; however, differences in dietary habits have been suggested to be one possible contributor.[17,18] Lifestyle modification, including diet and exercise, is the recommended initial intervention strategy for lowering BP.[19] In particular, the DASH (Dietary Approaches to Stop Hypertension) diet, which is rich in fruits and vegetables, low-fat dairy foods, fiber, and protein, and low in saturated fat, total fat, and cholesterol, has been found efficacious in reducing BP in hypertensive populations in a series of feeding studies as well as in free-living situations.[20–22] For example, the recently completed ENCORE (Exercise and Nutrition interventions for CardiOvasculaR hEalth) study demonstrated a significant decline in clinic and 24-h ambulatory BP among overweight, unmedicated outpatients with high BP randomly assigned to 4 months of the DASH diet with or without exercise and weight loss compared to usual diet controls (UCs).[22] However, it remains uncertain as to whether the DASH diet influences nocturnal BP dipping. The aim of the present study was to determine whether the DASH diet attenuates ethnic differences in nocturnal BP dipping in a sample of overweight, unmedicated AA and white participants with high BP, compared to participants randomized to a UC condition.

METHODS

The trial's design and methods are presented in detail elsewhere.[22] Briefly, the ENCORE study was a randomized trial comparing the effects of the DASH diet with and without weight loss. Participants were randomized to one of three conditions: (i) the DASH diet alone (DASH-A), (ii) the DASH diet combined with behavioral weight management (DASH-WM), and (iii) the UC; the primary endpoint was clinic BP while other biomarkers of cardiovascular health, including flow mediated dilation, baroreflex sensitivity, and insulin resistance served as secondary endpoints. Assessments were obtained prior to randomization and at the end of the 4-month intervention. Immediately following randomization, participants entered a 2-week controlled feeding period in which they ate according to their assigned diet. For the UC and DASH-A conditions, participants consumed study meals isocalorically, whereas participants in the DASH-WM condition consumed meals at 500-calorie-per-day deficit to allow for weight loss of one pound per week. Following this feeding period, participants ate their prescribed diets on their own for the remaining 14 weeks of the study. In the DASH-A condition participants received instruction in modifying the content of their diet to meet DASH guidelines and were instructed explicitly not to exercise or to attempt to lose weight. DASH-A participants received weekly 30–45-min group counseling on the DASH diet and were provided feedback on their dietary adherence. Those participants in DASH-WM received the same instruction on the DASH diet as the

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DASH-A group; however, their weekly group counseling sessions also included cognitive-behavioral weight loss strategies (e.g., self-monitoring internal cues of satiation) as well as supervised exercise sessions three times per week. Participants in the UC condition were asked to maintain their usual dietary habits for 4 months until they were reassessed and were told not to change their usual exercise habits or to lose weight. On a biweekly basis, their weight and BP were monitored and their health habits were assessed to ensure they had not joined any exercise or weight loss program.

Participants

As described in our previous publication,[22] the study sample consisted of 144 healthy, but overweight, men and women with above-normal BP (mean systolic BP (SBP) 130–159 or diastolic BP 85–99 mm Hg based on four separate screening visits). Additional inclusion criteria included being age ≥35 years, a body mass index (BMI) of 25–40 kg/m^2, sedentary, free from any medications known to affect the cardiovascular system, and any medical comorbidities that would preclude safe participation in the trial. This sub-analysis is limited to Caucasian (CA) and AAs (ethnicity defined by self-report) for whom daytime and night-time ambulatory BP readings were obtained at both baseline and postintervention. As noted in the primary publication of this clinical trial, 18 participants were missing ambulatory BP data. Additionally, night-time BP measurements were missing from six participants. Because the other minorities comprised such a small (n = 2) subset of the sample, they were not included, yielding 118 participants for this analysis. In addition, because only 9 AAs (vs. 32 CAs) were randomized to the DASH-WM condition, DASH-WM, and DASH-A (19 AAs vs. 19 CAs) participants were combined together to facilitate the examination of intervention effects of a DASH diet intervention on nocturnal BP dipping amongst CA and AAs.

Ambulatory BP monitoring

To assess diurnal variation in BP, participants wore an Accutracker II (Suntech Medical, Raleigh, NC) ambulatory BP monitor over a 24-h period.[23] This device provided BP measurements four times per hour during the waking day and two times per hour during sleep. Daytime and night-time BP measures were differentiated by diary reported sleep/wake times obtained concurrently. Sleep times were unavailable on (n = 19) participants at either baseline or postintervention time points. However, in an effort to utilize all available data, BP measurements were deemed as occurring during the night-time if obtained between 12:00 AM and 6:00 AM.[16,24] Mean daytime and night-time systolic SBP and diastolic BP values were computed based on all valid readings during the measurement periods. BP measurements were accompanied by a diary entry documenting posture, activity, and location.

Nocturnal BP dipping was computed as a ratio of daytime BP/night-time BP where a smaller ratio indicates greater nocturnal decline in BP. The day/night BP ratio provides a continuous measure of nocturnal decline. For descriptive purposes, participants were also classified as a either a dipper, defined by decrease in SBP from daytime to night-time values of greater than or equal to 10%, or a nondipper, classified as having less than a 10% decline in systolic BP from daytime to night-time BP averages.

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Weight and electrolyte assessment

Body weight was determined by a calibrated digital scale (Detecto; Cardinal Scale Manufacturing, Webb City, MO). Sodium (Na^+) and potassium (K^+) intake were estimated from urinary excretion during a 24-h period.[25] In addition, an estimation of glomerular filtration rate was calculated using a modified MDRD equation.[26] Differences in glomerular filtration rate have been proposed to explain variation in BP and BP dipping.[27]

Statistical analyses

All analyses were performed using SPSS for Windows (version 17.0; SPSS, Chicago, IL). Comparisons of baseline characteristics were carried out using independent *t*-test and χ^2 statistics. The effect of intervention was evaluated using general linear model functions. Separate models were estimated for each outcome. The fixed factor predictor variables in each model were an intervention indicator variable (DASH intervention vs. UC) and ethnicity (CA vs. AA). Covariates in each model included the corresponding preintervention value of the outcome, age, gender, BMI, and posture (% time upright). To test whether the effects of the intervention on nocturnal BP dipping varies by ethnicity, we tested the interaction between intervention and ethnicity. This study was not powered to detect interactions; however, we evaluated it and provide the associated *P* value. In exploratory subgroup analyses by ethnicity, we computed separate linear models to further explore intervention effects on nocturnal BP dipping. Finally, because intervention effects on weight and 24-h urinary excretion of Na^+ and K^+ could give rise to changes in nocturnal BP dipping, separate analyses adjusting for change in BMI and change in electrolyte excretion were computed to determine whether intervention effects on BP dipping were independent of these changes.

RESULTS

Baseline characteristics

Demographic characteristics and ambulatory BP averages for CA and AAs are presented in Table 1. In this sample AAs were more likely to be female and younger relative to CAs (*P*'s < 0.01). In addition, AAs displayed less nocturnal SBP dipping (t (116) = −2.51, P = 0.01) and were more likely to be characterized as a nondipper when compared to CAs (χ^2 (1) = 7.15, P = 0.007). Baseline ethnic differences in day/night SBP ratio remained significant after adjusting for age, gender, BMI, and posture (F (1, 112) = 8.07, P < 0.01). AAs also displayed greater 24-h urinary excretion of Na^+ and a higher estimated glomerular filtration rate as compared to CAs (*P*'s < 0.05).

Table 2 displays baseline demographic characteristics and BP measurements by intervention condition (DASH intervention vs. controls). There were no significant baseline differences between conditions with the exception of higher average daytime SBP among those randomized to the UC condition compared to assigned to DASH interventions (t (116) = 2.63, P = 0.01). Conversely, ethnic differences were observed when looking within condition: specifically, AAs in the DASH intervention condition had a greater proportion of females, had a higher BMI, and were younger than the CAs assigned to that condition. In addition, AAs in the DASH intervention had a lower day/night SBP ratio and thus a greater

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proportion of SBP nondippers (*P*'s < 0.05). AAs had a higher 24-h urinary excretion of Na^+ compared to CAs in UC condition.

Effect of DASH intervention on BP dipping

Table 3 displays postintervention and intervention-related changes in ambulatory BP by dietary intervention and ethnicity. As reported previously,[22] participants randomized to a DASH diet intervention showed a significant decline in ambulatory BP compared to those in the UC condition, which remained statistically significant after adjusting for baseline levels of ambulatory BP, age, gender, BMI, and posture (*P*'s < 0.05). In addition, there was a trend suggesting DASH intervention to be associated with improvements in day/night SBP ratio (F (1, 113) = 3.13, P = 0.08). Participants meeting criteria for high-normal BP or obesity randomized to the DASH intervention showed similar changes in BP dipping observed in hypertensive and nonobese individuals, respectively.

Next, we examined whether changes in day/night SBP ratio varied by ethnicity. The interaction between intervention and ethnicity was below statistical significance (F (1, 109) = 1.97, P = 0.16). However, because this study was underpowered to detect interaction effects, in exploratory analyses we examined pre/post differences in ambulatory BP in AAs and CAs separately. We found that AAs randomly assigned to a DASH diet intervention showed a greater improvement in SBP dipping when compared to AAs in the UC condition after adjusting for baseline levels of SBP dipping (F (1, 40) = 4.39, P = 0.04) independent of age, gender, BMI, and posture (F (1, 36) = 4.58, P = 0.04). However, no differences were observed for CAs randomized to DASH vs. UC (F (1, 68) = 0.13, P = 0.72). Consequently, at the end of 4 months of intervention with the DASH diet, AAs were no longer significantly different from CAs on this measure of nocturnal SBP dipping (F (1, 112) = 1.67, P = 0.20). Moreover, as a whole sample, differences in proportion of nondippers postintervention by ethnicity were no longer statistically significant (44% of AAs vs. 32% of CAs; χ^2 (1) = 1.75, P = 0.19).

The role of BMI and 24-h urinary electrolyte excretion

It is possible that intervention-related changes in BMI, Na^+, and K^+ excretion may account for the reduction of ethnic differences in day/night SBP and proportion of nondippers postintervention. Consistent with our prior report,[22] the DASH diet intervention was associated with a greater reduction in BMI relative to the UC group (F (1, 115) = 34.25, P < 0.001). However, when change in BMI was treated as a covariate in evaluating intervention-related changes in day/night SBP ratio separately in AAs and CAs, AAs in the DASH intervention continued to display a significant increase in day/ night SBP ratio compared to AAs in the UC condition (F (1, 36) = 4.34, P = 0.04).

Participants in the DASH diet intervention displayed a greater reduction in 24-h urinary Na^+ excretion (F (1, 115) = 12.00, P < 0.01) and a significant increase in 24-h urinary K^+ excretion (F (1, 115) = 3.83, P = 0.05) compared to UC controls. However, when compared across conditions, AAs in the DASH intervention showed little change in 24-h excretion of Na^+ (t (41) = 0.94, P = 0.35) and only a marginal increase in K^+ as compared to AAs in the UC control condition (t (41) = 1.87, P = 0.07). Nevertheless, separate models were computed to test whether change in Na^+ or K^+ accounted for improvements in SBP dipping among AAs. In this regard, AAs in the DASH intervention continued to display a significant improvement in SBP dipping relative to AAs in the UC condition after adjustment for change in Na^+ urinary excretion (F (1, 39) = 4.12, P = 0.05). In contrast, when change in 24-h urinary K^+ excretion is included as a covariate, AAs randomized to the DASH intervention no longer differed statistically from AAs in the UC control (F (1, 39) = 2.99, P = 0.09).

DISCUSSION

A growing literature demonstrates AAs to be at substantially greater risk for cardiovascular morbidity and mortality compared to CAs.[1–3] While the mechanisms underlying this disparity have yet to be fully elucidated, ethnic differences in nocturnal BP dipping may be an important contributory factor. In the present study, at preintervention baseline, nocturnal SBP dipping was significantly blunted in AAs relative to CAs, a finding that is consistent with several cross-sectional investigations.[4,6,8,28,29] In exploratory subgroup analyses, this study revealed that AAs randomized to the DASH intervention, with or without caloric restriction, displayed marked improvement in nocturnal SBP dipping relative to AAs in the UC condition. In contrast, CA participants derived comparatively little intervention-related benefit in BP dipping. Consequently, at postintervention ambulatory BP assessments, AAs no longer differed from CAs with respect to nocturnal SBP dipping.

The efficacy of DASH diet in reducing clinic, 24-h ambulatory BP, and mortality among patients with hypertension has been demonstrated previously.[20–22,30] However, few studies have examined the effect of the DASH diet on nocturnal BP dipping. In one such study, Moore *et al.*[24] showed significant declines in daytime and night-time SBP in a sample of healthy community volunteers randomized to an 8-week combination diet (rich in fruits and vegetables and low-fat dairy foods) vs. a control diet; however, this study failed to detect a statistically significant interaction between intervention and ethnicity. Interestingly, in a subgroup analyses, minorities randomized to the combination intervention, 90% of whom were AA, displayed significant declines in 24-h, daytime, and night-time BP compared to AAs in the control condition. Conversely, CAs failed to show statistically significant intervention-related changes in ambulatory BP. Similarly, a sub-analysis of the original DASH diet feeding trial has shown evidence of ethnicity moderating the BP lowering benefits associated with the DASH diet.[31] In this regard, AAs randomized to the DASH combination diet showed a greater reduction in clinic SBP compared to CAs, an effect that was most marked in participants with hypertension.[31] In the present study, we observed a trend for an intervention effect on nocturnal BP dipping (P = 0.08). And while this study was not powered to detect an interaction between ethnicity and intervention condition, the fact that the sub-analyses revealed that AAs randomized to the DASH intervention showed a greater improvement in SBP dipping when compared to AAs in the UC condition provides intriguing, albeit preliminary, evidence that the DASH intervention may confer a particular benefit for AAs. That said, interpretation of this modest, preliminary finding should be made cautiously.

The mechanisms that give rise to ethnic differences in BP dipping remain to be elucidated; however, environmental (e.g., socioeconomic disparities[8]), physiologic (e.g., elevated

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autonomic activation[32]), and behavioral (e.g., sleep disturbance[28]) factors appear to play a role. Dietary sodium and potassium intake also may be important.[33] In a prior report,[22] we noted that our DASH dietary intervention was associated with a reduction in sodium intake and increase in potassium intake; however, other DASH studies have failed to find this association.[20] In the present study, relative to CAs, AAs displayed greater baseline sodium intake, as assessed by 24-h urinary excretion, which remained high at postintervention. Moreover, change in sodium intake from baseline to postintervention did not account for differences in SBP dipping between AAs in the DASH intervention compared to those in the UC condition. Conversely, change in potassium intake did attenuate observed differences in intervention-related improvements in SBP dipping among AAs. While evidence supporting a link between potassium intake and BP dipping is limited, a prior study found a positive correlation between the magnitude of decline in SBP during sleep and urinary potassium excretion.[13] Further investigation into the role of potassium in BP dipping, particularly among overweight AAs with high BP is warranted.

The present findings should be interpreted in the context of several limitations. First, the effects were modest and derived from a relatively small sample of highly motivated participants. Second, because this study was not designed to examine ethnic differences specifically, few AAs were randomized to the DASH-WM condition. Consequently, we were unable to assess the relative impact of DASH-A compared to DASH-WM on BP dipping. The heterogeneity of the DASH condition in this sub-analysis (DASH-A and DASH-WM) is particularly relevant when considering differences in weight loss. As expected, participants in the DASH intervention showed a greater decrease in BMI relative to those in the UC; however, in subgroup analyses, adjustment for change in BMI had little effect on improvements observed in AAs in nocturnal SBP dipping.

In summary, this study replicates prior research showing baseline ethnic disparities in nocturnal BP dipping, with AAs evidencing blunted BP dipping compared to CAs with high BP. This study also provides preliminary evidence suggesting that the DASH diet intervention may improve SBP dipping in overweight AAs with high BP, which in turn, lessens ethnic differences in nocturnal BP dipping. Future research exploring the mechanisms by which the DASH diet affects nocturnal BP dipping in both CAs and AAs is warranted.

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Table 1

Baseline characteristics of the study sample

	Caucasian (n = 75)		African American (n = 43)		
	Mean	**s.d.**	**Mean**	**s.d.**	***P* value**
Age (years)	54.4	9.7	49.1	7.7	0.002
Gender (% female)	56.0%	—	81.4%	—	0.01
BMI (kg/m^2)	32.4	3.7	33.4	4.1	0.19
% obese (BMI ≥30)	72%	—	76.7%	—	0.57
Education (>high school)	68.0%	—	70.0%	—	0.84
Income (>$50 K/year)	66.7%	—	60.4%	—	0.50
% High-normal blood pressure	17.3%	—	9.3%	—	0.23
Daytime SBP (mm Hg)	142.2	13.0	140.7	12.4	0.55
Daytime DBP (mm Hg)	84.4	7.9	85.6	10.0	0.49
Night-time SBP (mm Hg)	123.2	16.0	126.9	15.4	0.23
Night-time DBP (mm Hg)	71.6	9.0	74.8	10.4	0.08
Daytime/Night-time SBP	1.16	0.1	1.12	0.1	0.01
Daytime/Night-time DBP	1.19	0.1	1.15	0.1	0.10
% SBP nondipper	26.7%	—	51.2%	—	0.01
% SBP reverse dipper (<0% dip)	5.3%	—	9.3%	—	0.41
% SBP extreme dipper (>20% dip)	14.7%	—	6.7%	—	0.16
Na^+ urinary excretion (mmol/24 h)	95.8	45.4	122.7	42.3	0.002
K^+ urinary excretion (mmol/24 h)	37.2	15.8	36.3	11.9	0.74
Estimated glomerular filtration rate (ml/min per 1.73 m^2)[a]	77.9	12.4	85.9	15.1	0.003

BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

[a] Caucasian n = 72, African Americans n = 40.

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Table 2

Baseline characteristics by dietary intervention and ethnicity

	DASH treatment				Usual control			
	Caucasian (n = 51)		African Americans (n = 28)		Caucasian (n = 24)		African Americans (n = 15)	
	Mean	**s.d.**	**Mean**	**s.d.**	**Mean**	**s.d.**	**Mean**	**s.d.**
Age (years)	55.1	10.0	49.8	8.4	52.9	9.6	47.9	6.5
Gender (% female)	52.9%		85.7%*		62.5%		73.3%	
BMI (kg/m^2)	32.1	3.6	34.4*	3.9	33.2	3.8	31.5	4.0
Daytime SBP (mm Hg)	140.1	12.9	139.1	12.2	147.4	11.7	143.7	12.5
Daytime DBP (mm Hg)	83.7	8.3	84.5	9.9	85.9	6.9	87.6	10.1
Night-time SBP (mm Hg)	122.1	17.5	127.5	14.8	125.7	12.3	125.7	17.0
Night-time DBP (mm Hg)	71.2	9.5	74.2	10.0	72.3	8.1	75.9	11.3
Daytime/Night-time SBP ratio	1.16	0.10	1.10*	0.07	1.18	0.11	1.15	0.11
Daytime/Night-time DBP ratio	1.19	0.13	1.15	0.09	1.20	0.12	1.17	0.13
% SBP nondipper	29.4%		60.7%*		20.8%		33.3%	
Na^+ urinary excretion (mmol/24 h)	95.3	45.0	115.8	44.6	96.8	47.1	135.7*	35.7
K^+ urinary excretion (mmol/24 h)	37.3	12.1	36.0	17.0	34.2	11.4	39.4	13.6
Estimated GFR (ml/min per 1.73 m^2)	76.7	12.2	86.6*	17.0	80.4	12.6	84.5	11.1

BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; GFR, glomerular filtration rate; SBP, systolic blood pressure.

* $P < 0.05$ when compared to Caucasians within condition.

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Table 3

Postintervention and intervention-related changes by dietary intervention and ethnicity

	DASH condition				Usual control			
	Caucasian (*n* = 51)		African Americans (*n* = 28)		Caucasian (*n* = 24)		African Americans (*n* = 15)	
	Mean	**s.d.**	**Mean**	**s.d.**	**Mean**	**s.d.**	**Mean**	**s.d.**
Daytime SBP (mm Hg)*	132.6	13.7	133.4	12.7	147.0	14.3	137.9**	12.7
Δ Daytime SBP (mm Hg)	−7.2	12.7	−5.7	13.3	−0.4	12.6	−5.7	10.1
Daytime DBP (mm Hg)*	79.5	7.8	82.1	11.0	87.1	8.5	85.2	8.0
Δ Daytime DBP (mmHg)	−4.2	7.7	−2.4	8.1	1.1	5.9	−2.5	7.2
Night-time SBP (mmHg)*	115.6	15.5	118.6	16.6	128.2	13.4	126.0	11.4
Δ Night-time SBP (mmHg)*	−6.5	10.9	−8.8	18.6	2.5	12.2	0.2	11.4
Night-time DBP (mmHg)*	67.8	8.7	71.6	11.8	73.4	8.9	75.3	8.9
Δ Night-time DBP (mmHg)*	−3.5	6.4	−2.6	12.5	1.1	7.3	−0.5	6.9
Day/Night SBP ratio	1.16	0.11	1.13	0.09	1.15	0.09	1.10	0.08
Δ Day/Night SBP ratio	0.0	0.11	0.04	0.10	−0.03	0.15	−0.06	0.09
Day/Night DBP ratio	1.18	0.12	1.16	0.11	1.19	0.11	1.14	0.09
Δ Day/Night DBP ratio	0.0	0.11	0.01	0.14	0.0	0.12	−0.03	0.11
BMI	30.1	3.8	33.3**	3.8	33.6	4.14	31.4	3.9
Δ BMI*	−2.0	1.8	−1.0**	1.9	0.4	0.9	−0.1**	0.6
% SBP nondipper	31.4%	—	35.7%	—	33.3%	—	60%	—
Na^+ urinary excretion (mmol/24 h)*	65.8	33.1	116.0**	55.2	112.8	53.2	120.7	36.0
ΔNa^+ urinary excretion (mmol/24 h)*	−29.5	34.8	0.30**	53.7	15.6	34.0	−14.9**	43.1
K^+ urinary excretion (mmol/24 h)*	48.5	20.5	47.0	18.3	41.7	19.0	40.5	10.4
ΔK^+ urinary excretion (mmol/24 h)	11.3	18.5	11.0	16.8	7.5	16.1	1.1	15.8

BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; SBP, systolic blood pressure; UC, usual diet control.

* *P* < 0.05 DASH condition vs. UC;

** *P* < 0.05 when compared to Caucasians within condition.